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THE DISEASE AS FOUND IN THE FIELD.

THE LEAF-SPOT DISEASE OF TOMATO

BY

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This disease caused a practical failure of the tomato crop in 1915. It may be expected to be serious whenever the season is moderately wet. It is probably the worst disease of the tomato. This bulletin discusses the cause of the disease and gives practical recommendations for control.

EAST LANSING
1917

CONCISE DIRECTIONS FOR CONTROL.

It is definitely known that *seedlings commonly carry the infection to the field.* The seed is not thought to carry the fungous spores. Therefore, if the soil in the flats or cold frame is clean the plants start clean.*

The disease is brought to the field on the seedlings.

To insure clean seedlings *spray the young plants at least twice* with weak Bordeaux mixture (2-2-50).

Spray young plants.

Do not follow tomatoes with tomatoes. *Have a systematic rotation for your fields.* Cleaning up of trash in garden patches and fields is a good sanitary measure. Do not throw old vines on the manure pile or compost heap.

The disease is known to live over from year to year in old diseased plants.

Where the type of culture permits, *staking* of tomatoes will largely prevent damage from tomato leaf-spot. Staked tomatoes give greater yields, earlier crops and allow most efficient spraying.

The spores splash from the soil and from the lower leaves.

After the plants are well started in the field, spray every 10 days with Bordeaux mixture 4-4-50, made exactly according to directions. The early sprayings are most important in preventing the disease from getting a foothold. When the plants are large, unless the application is thorough it will pay to spray down and back on the same row. This, if a gentle wind is blowing and if the sprayer gives a good mist, will insure a thorough application.

Tomato leaves can be protected by Bordeaux mixture.

Tomato leaves make a quick growth. *Frequent sprayings are necessary* to keep the new growth covered.

Frequent sprayings are to keep the new growth covered.

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*(1) Soil from fields which have not recently grown tomatoes is safe for use. Manure containing tomato trash is unsafe.

(2) Used soil may be sterilized by steaming by the inverted pan method.

(3) Used soil may be disinfected by drenching with formaldehyde 1 to 100 parts water. Use 1 gallon to the cubic foot, drenching the soil completely. A quart of solution will disinfect a flat. Cover with paper or canvas over night. Then turn the soil thoroughly to allow the fumes to escape. As soon as the soil is in good condition, plantings may be made. This treatment is simple, cheap and easy. It will also prevent damping off.

Fig. 2. Diseased plant showing the killing of the lower leaves.

INTRODUCTION*

Michigan is one of the great tomato-growing states. The crop produced amounts to nearly a million dollars annually. Tomatoes are grown for ordinary market purposes, for canning and for seed. The type of culture and the varieties used vary with the utilization of the crop. The methods used in growing the crop influence the prevalence of this disease to a great extent. For example, it is found that where tomatoes are staked, the damage from leaf-spot is greatly reduced. In general, seedlings are grown in greenhouses or cold frames and set by hand in the fields. This method of procedure lends itself readily to control measures which entirely prevent damage from the leaf-spot disease.

Michigan tomato crop is worth $1,000,000 annually.

THE IMPORTANCE OF THE LEAF-SPOT DISEASE.

The leaf-spot disease of tomato, commonly called by growers "blight," caused a practical failure of the crop in many localities in 1915, and for the preceding five years, has materially shortened each growing season. This condition is found in every state where tomatoes are grown commercially. The consensus of opinion of pathologists from all parts of the United States, is that the Septoria leaf-spot is the most serious disease of the tomato.

The leaf spot is the most serious disease of the tomato.

The disease has been found in the northern, as well as the southern parts of Michigan. Its distribution is probably as great as tomato culture.

The disease is as widespread as tomato culture.

HOW TO TELL THE DISEASE.

The signs of the leaf-spot disease are well expressed by the common name "blight." The growers notice a general unthriftiness in the plants along with a blight which begins on the lower leaves and which gradually advances upward on the plant. (Fig. 2.) Blighted leaves if carefully examined are seen to be covered with small circular spots, commonly less than 1/8 of an inch in diameter. In some cases a whole leaflet may be involved. These spots are sometimes black, but are usually grayish with a black border. (Frontispiece.) As the disease progresses the spots dry and the leaflets turn

Leaf spot shows up as a blighting of the leaves from the bottom upward.

*This popular bulletin is based on Technical Bulletin 25 of this Station. Anyone interested in the more detailed account may secure the technical bulletin so long as the supply lasts. Those who make request, may be placed upon the mailing list to receive bulletins from the College.

Spots appear on the leaflets. Then the leaves die, falling from the plant at the least jar.

yellow. The leaves die and drop from the plant at the slightest jar. The disease advances up the plant, and soon all leaves, except a small tuft at the end fall from the stem. The dropping of the leaves exposes the fruit, which may sunburn badly.

Spots are also formed on the calyx and stem but rarely on the fruit.

The leaves manufacture sugar and starch. The leaf spot disease destroys the factories.

The damage to the crop comes largely from the loss of the leaf surface. The leaves of plants are the manufacturing organs which produce the starch and sugars which make up the greater part of the solid matter of the fruit. A leaf disease interferes with the manufacturing power, hence, the

Fig. 3. Diseased spots magnified five times.

Small, sour, watery tomatoes are caused by leaf spot.

fruit grows slowly or not at all. Half-matured fruit fails to ripen. The crop from plants with blighted foliage is small, sour and watery. This last condition is often complained of by canners; although they ascribe "watery" tomatoes to a wet season, rather than to a fungous disease made severe by the season. In short, all the general signs are those which go with disturbance of food manufacture by the leaves.

THE CAUSE OF LEAF-SPOT.

A fungus steals from the tomato plant.

Leaf-spot of tomato is caused by a parasitic fungus called *Septoria lycopersici* which grows and feeds in the tomato leaf. A parasitic fungus is a microscopic plant which makes

no food for itself but which steals its living from another plant. If a diseased spot is examined with a microscope, the leaf tissue is found to be pierced by minute threads. These threads are the body of the fungous parasite. After the threads have grown in the leaf and occupied considerable area, small black dots appear on both the upper and lower surfaces. (Fig. 3.)

Needle-shaped spores are the "seeds" of this parasitic fungus.

The small black dots are hollow spherical cases which contain countless long needle-shaped bodies called *spores*. (Fig. 4.) These spores are to the fungus what seeds are to the higher plants. A spore washed to a tomato leaf and given favorable temperature and moisture will

Fig. 4. Thin section of spore case, showing long needle-shaped spores. Magnified 800 times.

sprout and enter the leaf, quite as a seed sprouts and grows, only the soil the fungus uses is the leaf tissue.

The spores float about on wet leaves, or,

The spores of this fungus have a jelly-like coat and when a diseased leaf is wet, the spores swell and push out of the spore cases in sticky masses. When the spores are once outside the spore case they float apart in the water on the leaf and frequently sprout and enter, thus making the spot larger or causing new ones.

Rains splash the spores about.

The spores from a diseased leaf may be washed or splashed from leaf to leaf during rains, or if the plants are worked when wet, may be carried from plant to plant on the cultivator or on the clothes of the worker.

Cultivating wet plants spreads the spores from plant to plant.

The spores can endure at least three days drying, hence, those which wash to the ground may be dried on the dust and blown about, thus leading to a wider distribution of the disease in the field or from field to field.

How the spore attacks the tomato leaf.

If a spore is put under proper conditions it will begin to sprout in about twenty-four hours. The sprouts are threads which push out from the needle-like spore. In a few hours after sprouting the thread-like tube enters the breathing pore of the leaf. Then the fungus grows in the tissues of the plant, twining among the cells. In about six days after the spore reaches the leaf, the first watery discoloration produced by the fungus can be seen. In less than ten days the spot is definite and the killing of the invaded leaf tissue is completed. The fungus fruits in about 13 days and produces several black spore cases. Hence, one spore gives rise to countless thousands of other spores, each capable of repeating this story.

In 13 days one spore produces thousands of similar spores.

Either the upper or lower surface may be the point of entry.

If the lower surface is the point of entry the spots are large and may involve one-half or the whole of a leaflet. If the upper surface is the point of entry the spots may be no larger than the head of a pin. Usually the upper leaves show this latter type of infection, evidently from dust as a source. The lower leaves are infected from beneath, doubtless by splashings from the ground or from the older leaves.

The fungus lives over on old trash from last year's diseased plants.

The fungus lives over winter on the trash from a preceding tomato crop. It lives over in the greenhouses or cold frame in the trash from seedlings left in the soil. The spores have not been found on tomato seed. Hundreds of plants from all the common varieties have been grown in clean soil without one case of leaf-spot appearing spontaneously.

The weather does not cause the leaf spot disease.

The spores of the fungus are released from the spore case only when the leaf is wet. Heavy dews give conditions which allow an oozing of spores. By far the greatest factor in spreading the fungus is a washing, splashing rain. Therefore, the disease is most serious in a rainy season such as that of 1915. Many growers make the mistake in thinking that the tomato disease is caused by the weather, while the truth is that the disease is caused by a parasite whose spread is favored by the wet conditions.

Growers must adopt measures which will insure a crop in spite of the weather.

HOW TO PREVENT LOSS FROM TOMATO LEAF-SPOT.

Resistant Varieties.

No resistant variety is as yet found.

In an experiment with more than 50 of the leading tomato varieties, no variety was found strikingly resistant or susceptible. Many varieties are vigorous growers and continually keep ahead of the leaf-spot by the production of new foliage. Dwarf varieties usually suffer more damage than the ordinary sorts.

Before other control measures can be considered, we must recognize the following observations that have been dealt with above:

Summary of facts about the disease.

1. The sources of infection are at least two: the greenhouse or the hotbed and the diseased trash in the field.
2. Infection results from inoculation upon the upper and lower surfaces of the leaf.
3. The period from the time of inoculation to spore exudation is about 13 days.
4. Moisture is the primary agent in dissemination of the disease.
5. The exudate of spores is in the form of a mucilaginous mass. The spores are always transferred by some external agency.
6. It has been shown that the fungus will not grow at 85° F. and will not revive after 5 days at 98° F. Since such temperatures are frequently reached during the summer months, the heat relation must be taken into consideration as a natural means of checking the disease.

Prevention methods necessary.

The most important control measures for this disease are preventive. Clean seedlings in clean soil, if reasonably isolated remain practically free from the disease.

Clean soil.

In order to be sure that the seedlings do not become diseased at the start, clean soil should be used in the greenhouses devoted to seedling production. The soil should be fresh or sterilized. The seedlings should be sprayed as soon as their height above ground makes it practicable, and again before being transplanted to the field. For this a weak Bordeaux mixture (2-2-50) is advised.

Destroy old trash.

Since it has been determined that wintered-over, diseased vines possess spores which are viable, the old trash must be destroyed as far as possible. Since, however, this is not practical except in greenhouses and gardens, rotation is strongly urged. While there is no experimental evidence to demonstrate the value of rotation as a means of control, numerous instances have been noted in which rotation has been successful in controlling the disease.

The spores are carried when wet.

Since spores are released from the spore cases when wet the plants should not be "worked" until the plants are dry. Growers have reported cases where cultivation began at a small infected patch and the disease was carried over the entire field, and that in less than three weeks the entire field was spotted. This is now readily explained. In greenhouse practice, irrigation should replace the ordinary use of the hose.

Spray with Bordeaux.

After transplanting to the field, spray with 4-4-50 Bordeaux mixture every 10 days. As has been shown, the period from time of inoculation to spore exudation is at least 13 days. Allowing this leeway for differences in period of infection, it would seem that a spray so applied would give the necessary protection.

Reasons for failures in control.

The greatest part of and the strongest infection results from inoculation on the lower surface of the leaf. Therefore, all the precautions are less effective if the plants are allowed to run at will over the ground. The spraying of the under side of the leaf is not accomplished unless the application is thorough. Failures to control the disease by spraying are doubtless due to lack of thoroughness and timeliness.

How to spray.

Spraying with 4-4-50 Bordeaux mixture in the fields where tomatoes are staked should be extremely successful. In this state spraying will not be most effective unless the spray reaches the lower surface of the leaves. A sprayer such as is used for potatoes, with two side nozzles set to shoot upward and if practical, with one central nozzle to spray downward for each row will, under high pressure, be most efficient in Michigan fields.

Spraying has succeeded in in Michigan.

Spraying tomatoes with Bordeaux is a common practice in many tomato-growing centers. Wherever it has been tried it has become a fixed part of the culture of the crop. No grower can afford to risk his crop, and no company can afford to risk its acreage. The spraying experiment of the College in 1913 at Plymouth is a good example of what may be accomplished. In this experiment "the plants that were sprayed with Bordeaux mixture four times, produced 12.5 tons per acre while the plants that were not sprayed produced 5.2 tons per acre. The first spraying was made about one month after the plants were set in the field and frequently enough afterward to protect the new growth." (Every ten days or two weeks).*

Copper sulphate (Bluestone or Blue Vitriol) is a little more expensive this year than formerly. In spite of the cost, spraying is a crop insurance which is most strongly to be advised.

*Eustace, H. J., Mich. State Board of Agriculture Report 1914:234.

THE SPRAYER.

The type of sprayer depends upon the acreage and method of culture. The market gardener can control tomato leaf-spot with a small knapsack or hand sprayer. Knapsack sprayer for the small grower.

Tomatoes are commonly grown in fields of 5 to 10 acres. For fields of this type a horse-drawn traction sprayer is to be advised. However, efficient work can be secured by means of a handpower barrel pump mounted on a truck. This is the cheapest form suitable for field conditions and may be rigged up for from $25 to $40. Horse-drawn traction sprayer for the ordinary field.

For large acreages or for community or company use, a power sprayer is the best investment. Such an outfit will put the Bordeaux on most efficiently and will give the maximum protection. The sprayer for large acreages.

ARRANGEMENT OF NOZZLES.

Arrange the nozzle to spray upward.

The necessity of spraying the under side of the leaves makes the arrangement of nozzles important. The accompanying diagram shows the arrangement believed to be most efficient.

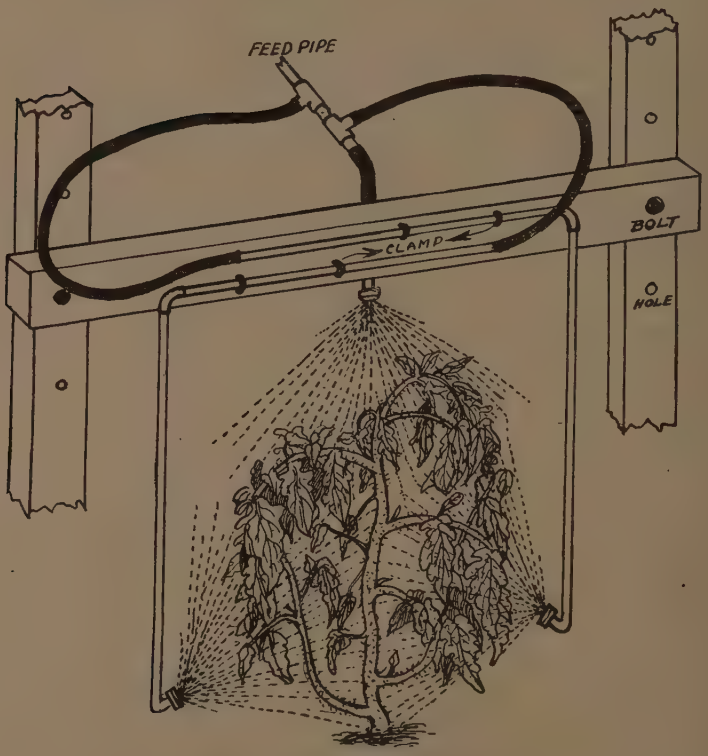

Fig. 5. Arrangement of nozzles.

With such a setting of nozzles the leaves can be efficiently covered without repeating the spray in the reverse direction.

Spraying the best you can is better than none at all.

Any spraying outfit can be adjusted to suit the needs of the crop, by use of a few pipe fittings. The accompanying diagram suggests a cheap, easily arranged setting. (Fig. 5.) Spraying is worth while even if the outfit is not ideal, or the nozzle arrangement perfect. Given good Bordeaux, thoroughness of application with pressure enough to produce a mist, and the investment will yield good returns.

THE MAKING OF BORDEAUX.

FOR SMALL ACREAGES.

(1) Saw a 50-gallon barrel (vinegar or oil) and make two 25-gallon tubs.

(2) Put 2 pounds of Bluestone (called Blue Vitriol or copper sulphate) in a cloth sack and hang over night in one-half tub of water (12½ gallons). Bluestone dissolves slowly. Hang it the night before so that the sack is just under the surface of the water.

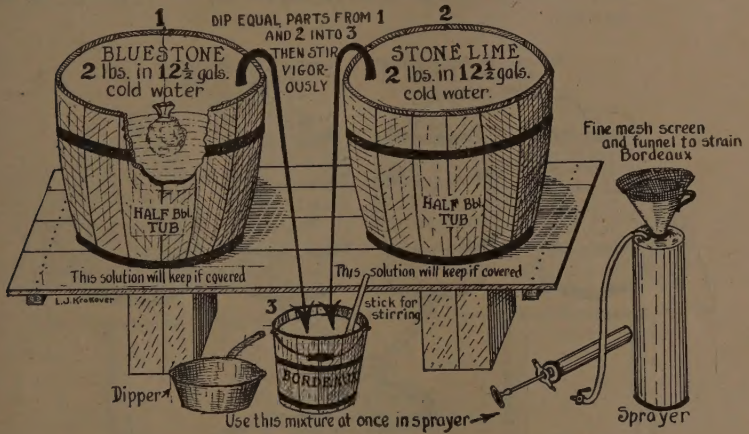

Fig. 6. How to make Bordeaux mixture for small acreages.

(3) Make a lime paste by slaking 2 pounds of fresh stone lime in one-half pail of water. Stir this into the half tub (12½ gallons) of cold water. Hydrated lime (comes in sacks) may be used. Use 2½ to 3 pounds of hydrated. Then follow the directions in the picture. This method will make 25 gallons of spray.

FOR LARGE ACREAGES.

To make 100-gallon batches.

Bordeaux 4-4-50 or 8-8-100 formula.

(1) Secure four 50-gallon barrels.

(2) Fill barrel No. 1 half-full, and hang 25 pounds of Bluestone so that the Bluestone is just under the surface of the water. This makes stock Bluestone, 1 pound to the gallon.

(3) Fill barrel No. 4 half-full of water and stir 25 pounds of freshly slaked stone lime or about 30 pounds hydrated lime in it. This is the stock lime paste, about 1 pound to the gallon.

The stock solutions will make 300 gallons of spray. They will keep if covered.

(4) Take 8 gallons stock Bluestone from barrel No. 1 and add to 42 gallons of water in barrel No. 3. (That is, fill the barrel).

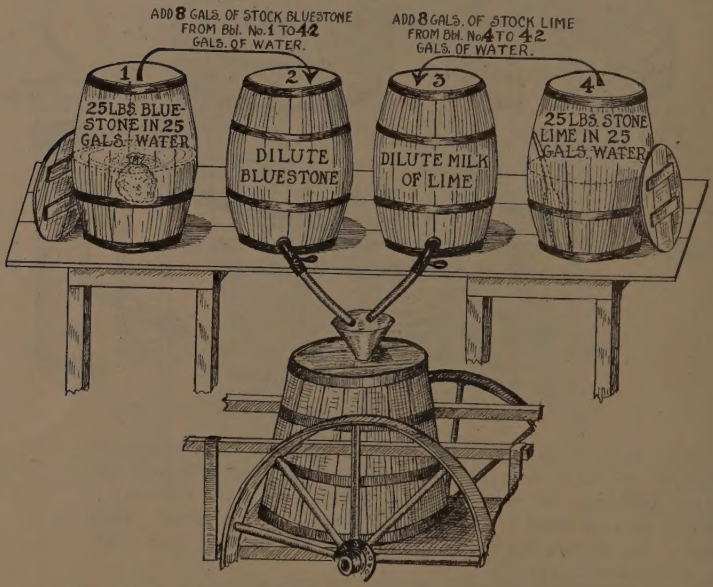
ADD 8 GALS. OF STOCK BLUESTONE FROM Bbl. No. 1 TO 42 GALS. OF WATER.
ADD 8 GALS. OF STOCK LIME FROM Bbl. No. 4 TO 42 GALS. OF WATER.
1
2
3
4
25 LBS. BLUESTONE IN 25 GALS. WATER
DILUTE BLUESTONE
DILUTE MILK OF LIME
25 LBS. STONE LIME IN 25 GALS. WATER

Fig. 7. How to make Bordeaux mixture in 100 gallon amounts.

(5) Take 8 gallons of stock lime from barrel No. 4 and add to 42 gallons of water in barrel No. 3.

(6) Run these materials together through a strainer into the sprayer tank. The combination is Bordeaux mixture and must be applied at once.

If the spray tank holds only 50 gallons make the dilution on one-half the above scale. The first batch may be tested with litmus paper to make sure that there is lime enough. If blue litmus paper turns red, add more lime. *With good fresh lime using the amounts given, no test is needed.* If weather conditions prevent the using of a batch of Bordeaux, it may be kept for a long time if cane sugar is added at the rate of one-half pound to 50 gallons.